Clinical application of QT dispersion on ventricular hypertrophy using magnetocardiogram

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1 Introduction

QT dispersion is defined as the difference between the maximum QT and minimum QT intervals on standard 12-lead electrocardiogram (ECG). It is a new index of the homogeneity of ventricular repolarization and considered to be a marker for the risk of malignant ventricular arrhythmia [1, 2]. There have been, however, no detailed studies except in myocardial infarction on QT dispersion using magnetocardiogram (MCG) [3]. The MCG can detect cardiac electric currents with high positional resolution compared to the ECG, which detects the electrical difference in electrical potential [4]. In addition, the location of the source of the electric current can be non-invasively determined by MCG [4]. In the present study, QT dispersions in patients with left or right ventricular hypertrophy were studied using the MCG.

2 Subjects and Methods

The MCGs were recorded using a second-derivative rf-SQUID gradiometer in 30 patients with left ventricular overloading (LVO group; essential hypertension) and 17 patients with right ventricular overloading (RVO group; 5 with pulmonary stenosis, 4 with tetralogy of Fallot, 6 with primary pulmonary hypertension, and 2 with obstructive pulmonary disease). Fig. 1 shows the 36 recording points on the anterior chest wall with the xyphoid process as reference (E-2) to determined the 36 lead points by 6·6 grid system. The points were labeled in order A, B, C, D, E, and F from head to foot, and 1, 2, 3, 4, 5, and 6 from right to left. Each grid was 2.5 cm · 2.5cm and covered the left anterior chest wall. The subjects lay on a wooden bed in the supine position, the detector was placed close to the anterior chest and magnetic field perpendicular to the anterior chest was recorded. As a reference, the lead II ECG was recorded at a paper speed of 200 mm/sec simultaneously with the MCG (Fig. 2). From the MCG waveforms of the 36 recording points over the anterior chest wall, QT time and R-R interval were measured and corrected QT (QTc) dispersion was calculated by Bazett's formula. The correlation between QTc dispersion and maximum dipole moments at the ventricular depolarization phase, and systolic pulmonary pressure were studied in the LVO and RVO groups. In addition, to evaluate the spatial and temporal distribution of QTc time at each lead, an isochron map was made and compared with the location of the electric source of the ventricular depolarization vector.

The position and strength of current dipole (dipole moments) of the heart were calculated using single dipole model [5]. The position of the current dipole is under the midpoint between source and sink. The depth (d) below the detecting coil and dipole moment are defined as follows:

$$D = D/2^{1/2},\ Q = 4\pi d^2 Bm/0.385\mu_0$$

where D and Bm are the span between extrema and maximum field, respectively.

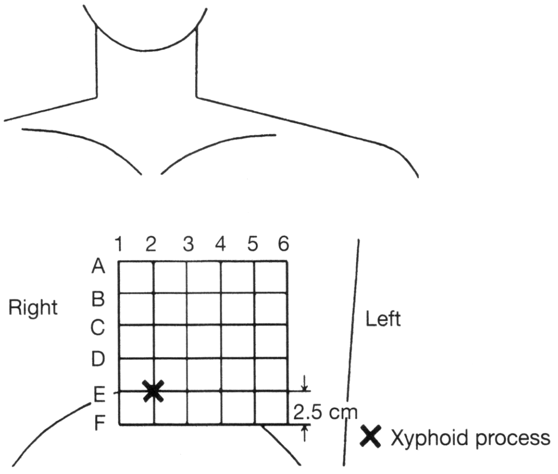

Figure 1: *Recording points of MCG.*

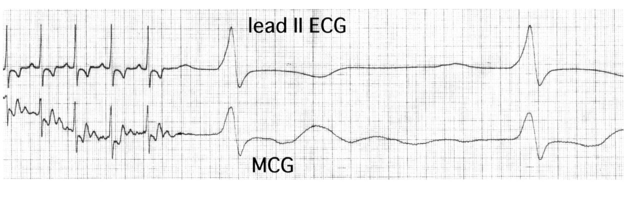

Figure 2: *Example record of lead II ECG and MCG (paper speed of 200 mm/sec).*

3 Results

3.1 Magnetic isofield map and QTc-isochron map in the LVO group.

The QT time of the LVO group was prolonged at left portion of the anterior wall, i.e., over the hypertrophic left ventricle. Fig. 3 shows an example of the magnetic isofied map (a) and QTc-isochron map (b) during depolarization in the LVO group. In the QTc-isochron map, prolongation of the QTc time was observed in the left precordial region, where the current source of the ventricular depolarization was largest on the magnetic isofield map.

Fig. 4 shows the correlation between the dipole moment of the maximum ventricular depolarization vector and QTc dispersion in the LVO group. There was a significant positive correlation between the dipole moment of the maximum ventricular depolarization vector (dipole moment) obtained from the magnetic field distribution map and QTc dispersion (r = 0.56, p < 0.01).

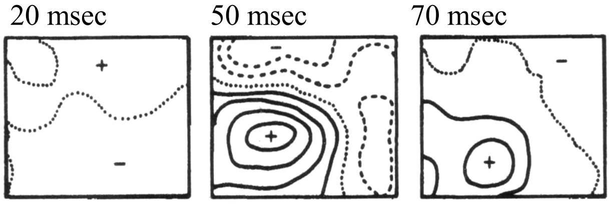

Figure 3a: *Isofield map of a patient with essential hypertension at 20, 50, and 50 msec from the beginning of QRS wave.*

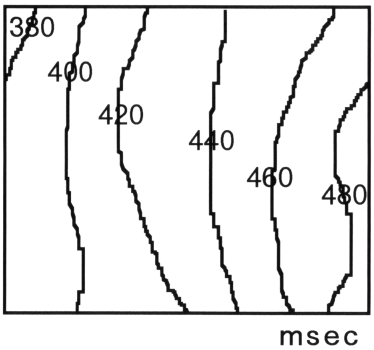

Figure 3b: *QTc-isochron map of a patient with essential hypertension.*

3.2 Magnetic isofield map and QTc-isochron map in the RVO group.

The QT time of the RVO group was prolonged at right lower portion, i.e., over the right ventricle. Fig. 5 shows an example of the magnetic field distribution map (a) and QTc-isochron map (b) during depolarization in the RVO group. The QTc isochron map showed prolongation of the QTc time in the right lower precordial region. This site corresponded with the electric current source of the maximum ventricular depolarization.

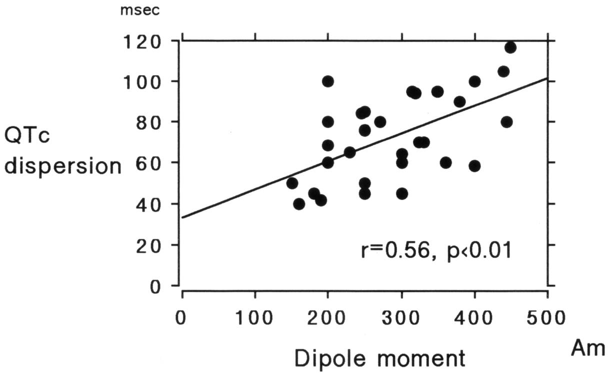

Figure 4: *Correlation between the dipole moment of the maximum ventricular depolarization vector and QTc dispersion in the LVO group.*

Fig. 6 shows the correlation between the pulmonary arterial systolic pressure and QTc dispersion. A significant positive correlation was observed between pulmonary arterial systolic pressure and QTc dispersion (r = 0.58, p < 0.01).

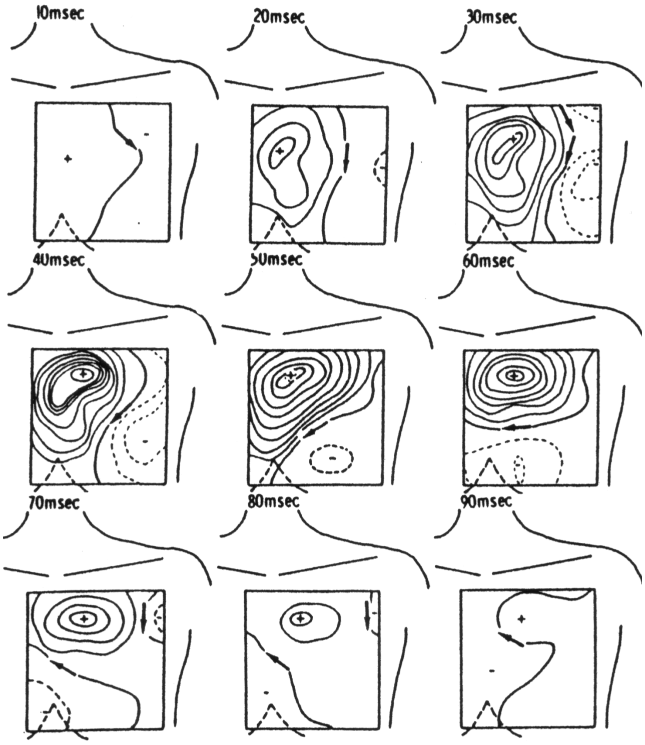

Figure 5a: *Isofield map of a patient with pulmonary stenosis at 10 - 90 msec from the beginning of QRS wave.*

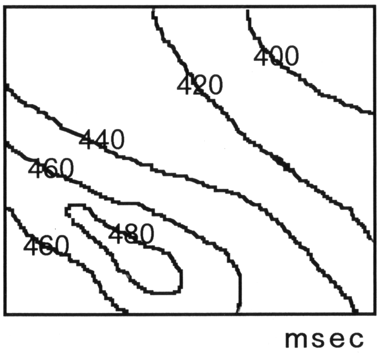

Figure 5b: *QTc-isochron map of a patient with pulmonary stenosis.*

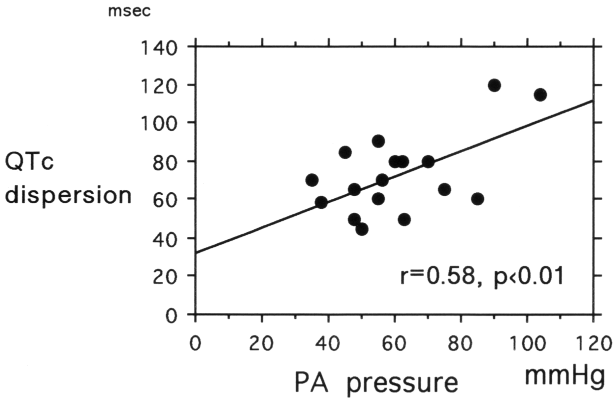

Figure 6: *Correlation between the pulmonary arterial systolic pressure and QTc dispersion in RVO group.*

4 Discussion

QT dispersion is considered to be closely associated with the severity and prognosis of cardiac disorders [6]. A relationship between the severity of ventricular hypertrophy and QT dispersion using ECG has been reported in patients with hypertension by Ichkhan *et al.*[7] and Mayet *et al.*[8] in patients with tetralogy of Fallot by Gatzoulis *et al.*[9]. However, there have been no studies using the MCG.

In the present study, in the patients with left ventricular overloading, there was a correlation between the dipole moments of the ventricular depolarization vector and QTc dispersion, and QT time prolongation was observed at the lead just above the hypertrophied myocardium of the left ventricle, indicating its relationship with left ventricular hypertrophy. In patients with right ventricular overloading, a close relationship was also observed between the hypertrophied myocardium and QT time prolongation.

In conclusion, MCG closely reflects the cardiac electromotive force right below the magnetic sensor. The results of the present study suggested a relationship between increased QT dispersion among the leads and ventricular hypertrophy, which might, in part, explain arrhythmogeneity of ventricular hypertrophy.

References

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